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Errors in short run forecasts next-day volatility of equity risk premium in the UK and U.S. market: Empirical research before and after the global financial crisis

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Abstract

The current article has focused on the comparison of the equity risk premiums' development in the two largest equity markets in the world, the U.K. and U.S. markets. The investigation has been made through estimating short run forecasts and calculating their errors. Therefore the aim of the study is to estimate errors in short run forecasts next-day volatility of the equity risk premium in the UK and U.S. markets. As the estimation method it used GARCH (1,2). It is obtained daily data for the period from 1999 to March 2014. The results have clearly proved that errors of forecasts are still at a higher level nowadays, than before the global financial crisis. Finally, it created a motivation for a future research in that area due to differences between types of financial systems.

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***Keywords*: Equity risk premium, short run forecasting errors, GARCH (1, 2) model;**

1. Introduction

An issue of the equity risk premium has a very long history among the researchers from the world. Many of them investigated the risk premium within the whole 20th century, divided into a few sub-periods, according to the first and the second World Wars as well as other U.S. wars, due to the Great Depression in USA and its ex post period after 1930, but also due to other financial crises in the second half of the century (Leblang and Mukherjee, 2005; Naifar, 2012; Prat, 2013; Huang et al., 2013) A predictability of the premium

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and even the forecasting of stock returns as well, was also often investigated using especially GARCH method (Chou, 1988; Nelson, 1991; Park, 2005). The global financial crises from the start of the 21st century have discontinued much of that research investigation. After the crisis it has been changed developments of many global economic and financial variables, even whether its past developments could been classified as usual in global view (e.g. natural gas and the oil prices' development, the correlation between bonds and stock prices, relationships between market interest rates and interest rates on loans). However, the global financial crises has affected the problematic of the equity risk premium, too.

The aim of the current paper is to estimate errors in short run forecasts next-day volatility of the equity risk premium in the UK and U.S. markets. The study compares two sub-periods from 1999 to March 2014. Ewijk et al., 2012 argues that the equity premium is a key parameter in asset allocation policies. There is a vigorous debate in the literature regarding the actual measurement of the equity premium, its size and the determinants of its variation. This paper contributes in two ways. First, it has expanded a very small number of related studies by providing evidence for new issues. Second, to explore the UK equity risk premium, it obtained interest rates due to Maastricht criterions for the first time. It was found that the development of the equity risk premiums is very similar in both economies, even despite the fact of using U.S. short term as well as long term interest rates in the UK.

The structure of the article is as follows. After the introduction there is a brief review of an existing literature connecting with this issue. Literature review is followed by a description of the data and methodology, used in the empirical part of this study. Next section is a discussion on empirical results also together with a creation of motivation for future research. Finally, the last part with concluding remarks concludes the paper.

2. Literature Review

Ewijk et al., 2012 determined the effects of several factors on the equity risk premium. Of course, the first factor is the applied methodology to measure the equity premium. Variation in the equity risk premium is the result of calculating equity premiums ex post or ex ante, average returns arithmetically or geometrically and using T-bills or bonds as the risk free rate. The second factor is the variation over time. They argue that several authors have pointed to a possible downward trend in the equity premium over time, which can be explained by the development of financial markets allowing for better diversification of risks. One difficulty in their analysis is that the underlying studies use different periods of observation, both in length and in precise dates. This makes it difficult to accurately pin down an observation of the equity premium to a certain period. The third factor concerns the spatial dimension. They find significant differences in equity premiums between the United States on the one hand and Canada, Secondary Emerging Countries and the Asian Tigers on the other hand. Emerging countries have a larger equity premium than the United States, whereas Canada has a lower equity premium. For Oceania (including Japan) and Western Europe the differences in comparison with the United States are small and statistically insignificant. Finally, they have looked into some underlying determinants of the equity premium. The equity premium tends to be higher in periods and countries with larger economic volatility. There is also a clear negative effect of the interest rate, indicating that the return on equity does not vary one-for-one with changes in the interest rate. This also implies that the return on equity cannot be determined by adding a constant equity risk premium to a time varying short or long interest rate. The rate of return on equity has its own dynamics which is only partly associated with the dynamics of the interest rate.

Donadelli and Persha, 2014 argue, the average equity risk premium in emerging markets is well-known to be significantly higher than in developed markets. They founded also that correlations between industrial stock market excess returns, but even a measure of global economic policy uncertainty are consistently

negative, and follow similar patterns. Their study is unique but it suffers a bit from the sample of selected countries. For example, they used also some economies with strong bank based systems, i.e. the Czech Republic. We have a very weak capital market from the view of trading volume as well as from initial public offerings (IPO) in our country. Just 14 companies made IPO of its shares within the Prague Stock Exchange. Even three of them represent more or less 80% from whole Czech market capitalization.

Nelson, 1991 argues that GARCH models have been applied in modelling the relation between conditional variance and equity risk premium. These models have in according to his opinion at least three major drawbacks in asset pricing applications: (i) He found a negative correlation between current returns and future returns volatility. (ii) GARCH models impose parameter restrictions that are often violated by estimated coefficients and that may unduly restrict the dynamics of the conditional variance process. (iii) Interpreting whether shocks to conditional variance "persist" or not is difficult in GARCH models, because the usual norms measuring persistence often do not agree. Nevertheless, Ewijk et al., 2012 argue that the equity premium can be measured ex post or ex ante. In ex post studies the equity premium is calculated as the difference in the historical mean return on stocks, either taken geometrically or arithmetically, and the risk free rate, mostly the short term interest rate (T-bills) or long term government bonds. Ex ante studies, in contrast, take the dividend yield or the price–earnings ratio as a starting point and derive the implied equity premium using an estimate for the capital gains.

3. Data and methodology

It obtained Maastricht criterion interest rates data for the UK from Eurostat, international statistical database, interest rates of three months U.S. Treasury bills from Fred, St. Louis FED economic database, and daily returns of two representation stock indices as well. As usually researchers do, it is obtained S&P 500 index's data for U.S. and FTSE 100 index's for the UK equity market. All data is in daily frequency and our estimation period is from January 1999 to March 2014.

Firstly, it was necessary to fill some gaps in time series due to missing data, which exist because of different holidays as well as due to some audits or different non-trading days in both economies. It is done through using the same data, the last before data missing. The equity risk premium' development is then explained ex post as a spread between growth changes of stock prices against interest rates of debt market. In Table 1 we can see all combinations and impacts of possible changes of selected variables and its impact on the risk within the UK and U.S. market in percentages. Assumptions included in Table 1 are consistent in basics with Donaldson and Mehra, 2008. They argue, since disaster states are ones of extremely high marginal utility of consumption, we might expect their incorporation to push up risk-free asset prices and diminish risky ones. As a result, the premium should rise (Donaldson and Mehra, 2008, p. 82).

Table 1. Possible changes and its impact on the market risk

% change of stock prices	% change of interest rates	Impact
Positive	Positive	Lower risk
Positive	Negative	Higher risk
Negative	Negative	Lower risk
Negative	Positive	Higher risk

Figure 1 shows then a simply calculated equity risk premiums' volatility within the whole period from 01/1999 to 03/2014. While for the examining of U.S. equity risk premium, it used short term interest rates of

U.S. T-bills as usual, for the examining of the equity risk premium in the UK, it is used Maastricht criterion interest rates for the first time. Of course, it should be very bold assertion that the British pound could be replaced by the euro. Nevertheless, even if it is obtained Maastricht criterion interest rates data in the UK, as we see, both calculated equity risk premiums have very similar development. There is also very broad debate nowadays, how much the problems within the EMU could have affected the UK economy. Therefore, an effort to make a calculation of equity risk premium in the UK by using this method, seems to be correct.

Figure 1 shows that a volatility of both premiums is very similar. However, we see that U.S. equity risk premium is affected more by the global financial crisis than the UK premium. Within the UK premium the minimum value is -9.35% and 9.31% is the maximum. The minimum value of U.S. intraday equity risk premium is -9.41% and the maximum is 10.98%. Standard deviation which means the market risk is also a quite similar. Within the UK it is 1.22, whereas within the U.S. it is 1.27.

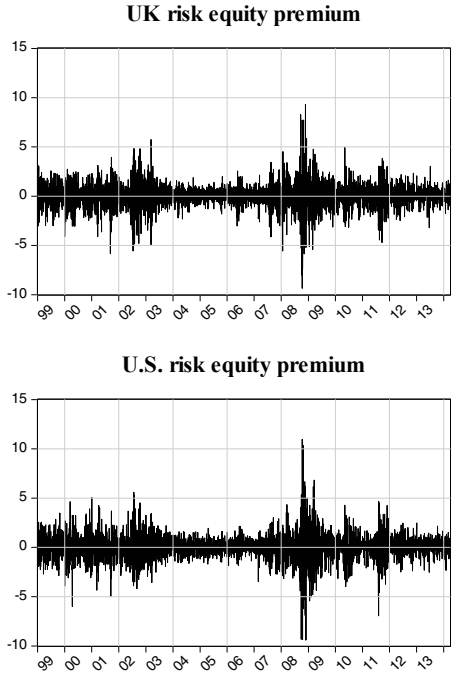

Fig. 1. Volatility of the UK and U.S. equity premiums in %

Methodologically it used volatility GARCH-M (1, 2) model. An equation of GARCH with a variance in mean model (1) and its variance equation (2), is described in according to Asteriou and Hall, 2011:

$$Y_t = \alpha + \theta_i h_t + \beta_i Y_{t-1} + \varepsilon_t \,, \tag{1}$$

$$h_t = \alpha_0 + \sum_{i=1}^{1} \varphi_i \, h_{t-1} + \sum_{i=1}^{1} \omega_i \, h_{t-2} + \delta_i Y_t + \gamma_i Y_{t-1} + \sum_{j=1}^{2} \vartheta_j \, \varepsilon_{t-j}^2 \,, \tag{2}$$

where Y_t means change of equity risk premium of i (the UK or U.S. market) in time t, GARCH is h_t, ε_t means residuals, and α is a constant. Within the model it is used a Generalized Error Distribution (GED) assumption. Asteriou and Hall, 2011 indicated that GARCH models also allow us to add explanatory

variables in the specification of the conditional variance equation. Due to them it might help to explain the variance better. Therefore it is added explanatory $\gamma_i Y_{t-1}$, but even also dependent variable $\gamma_i Y_{t-1}$ into the conditional variance specification within equation (2). Symbol $\sum_{j=1}^{2} \vartheta_j \, \varepsilon_{t-j}^2$ it means an ARCH process as a sum of the squared residuals. $\sum_{i=1}^{1} \varphi_i \, h_{t-1}$ and $\sum_{i=1}^{1} \omega_i \, h_{t-2}$ symbols mean GARCH(-1) and GARCH(-2) in the variance equation of GARCH-M (1, 2) model. In according to Franke et al. 2011, for short run forecasts next-day volatility of the equity risk premium it is used both, GARCH-M (1, 2) as well as non-parametric model based on historical volatility.

4. Discussion on empirical results

Table 2 shows just an estimation output for GARCH in mean models. The estimated period is divided due to declaring bankruptcy of Lehman Brothers into two sub-periods, before and after 15th September 2008 as a start of the global financial crises. We see that all last-day volatility coefficients β_i are negative. This founding have supported the arguments of Donadelli and Persha, 2014, and Nelson, 1991. The only one coefficient, the U.S. before the crises, it is positive. But we can see that an ARCH term ϑ_j is negative in this case. Because of an ARCH term means a sum of squared residuals from the variance equation (2)$\sum_{j=1}^{2} \vartheta_j \, \varepsilon_{t-j}^2$, the estimation output is not in a good condition. It has to be always positive. But it is definitely possible to make short run forecasts next-day volatility of the UK as well as U.S. equity risk premiums from whole period and then compare its errors in two sub-periods.

Table 2. GARCH-M models' output

Method: ML - ARCH (Marquardt) - Generalized Error Distribution (GED)						
Variable	*UK*	*before*	*after*	*U.S.*	*before*	*after*
θ_i	-0.2094	-2.6169	-0.2890	-1.1951	3.8003	-0.1350
α	0.2842	4.7228	0.4177	1.5999	-5.6831	0.2522
β_i	-0.0643	-0.2016	-0.0650	-0.2436	0.2020	-0.0789
Variance Equation						
α_0	0.0292	1.0223	0.0051	0.0116	0.4311	0.0094
ϑ_j	0.0362	0.0184	0.0032	0.0009	*-0.0331*	0.0109
φ_i	0.8866	0.5402	1.7998	1.6822	0.5899	1.7467
ω_i	0.0482	-0.1053	-0.8075	-0.6911	0.1219	-0.7656
δ_i	-0.1687	-0.3747	-0.2372	-0.2537	0.2641	-0.1679
γ_i	0.0616	0.1252	0.2265	0.2362	-0.2073	0.1365
GED	1.4882	0.1647	1.3137	0.9184	0.1606	1.3187

Note: All values are statistically significant at 1 % level.

Figures in Appendix A.1 show just forecasts of estimated volatility models and forecast of variance, both in graphs. We see that GARCH models' forecasts are very similar in graph and forecast variance is always positive. Therefore, it is made fitted residuals for short run forecasts next-day volatility of equity risk premiums as an exponential function, as well. Appendix A.2 shows negative correlation of risk premium with its historical values. It complies and support the arguments of Nelson, 1991. He proved such negative correlation as one of major drawbacks within GARCH. Even whether somebody uses GARCH models for forecasting, it can be also accepted the argumentation of Taleb, 2010. He argues that while these methods

represent a good effort, they fail to address the bell curve's fundamental flaws (Taleb, 2010, p. 278). In Appendix A.3 we can see that there is no heteroskedasticity within residuals of estimated GARCH-M models to contrast with heteroskedasticity problem within residuals of estimated OLS regression for both cases.

In Figure 2 we see higher volatility among errors in short run forecasts next-day volatility of equity premiums not only in global financial crises period. We see smaller errors in non-crises periods. But we can argue that the post-crises errors' development is very similar as in pre-crises period. Also therefore the estimation output seems to be in a good condition. As time period with the highest power for the forecasts in both economies we can clearly highlight the period from 2004 to 2007. During the global financial crises there was a higher volatility within development of errors in U.S. premium's forecast with maximum 31.30%.

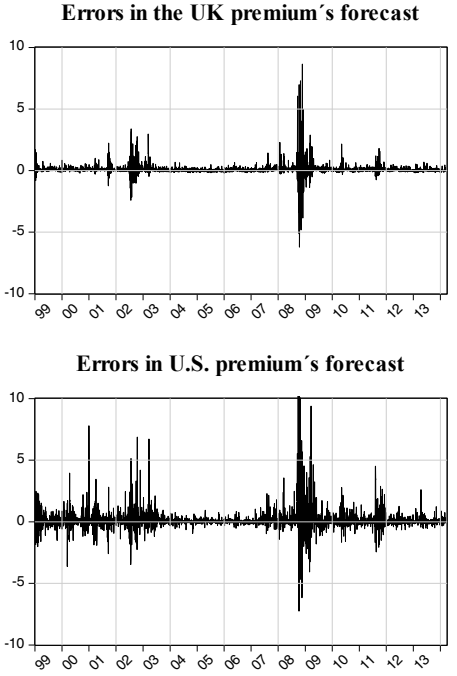

Fig. 2. Errors in short run forecasts next-day volatility of equity risk premiums

Table 3 concludes as descriptive statistics of premium forecasts' errors. It is very interesting how a higher risk is expressed by standard deviation of errors in short run forecasts next-day volatility of U.S. equity risk premium. While the standard deviation within the UK premium forecasts' errors is 0.47, within U.S. forecasts' errors it is 0.90. From this point of view, the short run forecasts next-day volatility of equity risk premium is in better condition with using long term interest rates in the case of the UK (Maastricht criterion interest rates), than in the case of U.S. premium with short term interest rates (T-bills).

We can argue that because of Figure 1 and its descriptive statistics. Both, the UK as well as U.S. equity risk premium, it seems to be very similar even weather it is used long against short term interest rates. The equity risk premium's development is better calculated using long term interest rates from this point of view (i.e. interest rates of government bonds, not just interest rates on T-bills).

Table 3. Descriptive statistics of premium forecasts' errors

	UK premium	U.S. premium
Mean	0.0598	0.0822
Median	0.0059	0.0014
Maximum	8.6428	31.3003
Minimum	-6.2192	-7.2521
Std. Dev.	0.4688	0.9005
Skewness	3.1626	12.2466
Kurtosis	100.79	386.67
Jarque-Bera	1590102	24473135
Probability	0.0000	0.0000
Sum	237.74	326.63
Sum Sq. Dev.	873.31	3221.66
Observations	3974	3974

Finally, through the generalization of reached results in this paper, we could not say that if we cannot estimate forecasts of risk premiums' development in such economies as the UK and USA without errors, it is impossible to forecast that in other developed economies, as well. Even if these two countries have been obtained because their economies are usually mentioned as the biggest Market based systems. Nevertheless, we should definitely differ between M-system and B-system. In bank based systems, banks (not markets) have a key role in financing households and companies. Therefore we have to strictly reject the generalization of this problem.

5. Concluding remarks

The aim of the paper was to estimate errors in short run forecasts next-day volatility of the equity risk premium in the UK and U.S. market. Because of the estimation results it is argued, the equity risk premium is better to be examined by using long term interest rates in the UK than U.S. short term interest rates. However, it is highlighted within the whole problematic of short run forecasts next-day volatility of equity risk premiums, there are some errors. Moreover, forecasts' errors after the global financial crisis are at higher level in both economies than in pre-crisis period. Therefore it is not objective use the forecasting to make any particular suggestions or even implications.

Nevertheless, the question is, weather the situation in developed Bank based systems will differ from these results. If would be proved that there exist a bigger differences within errors in short run forecasts of equity premiums' development among the both, developed B-system as well as developed M-system, it could be argued then, developments of the equity risk premium within capital markets differ due to differences between types of financial systems. It motivates the future research, too.

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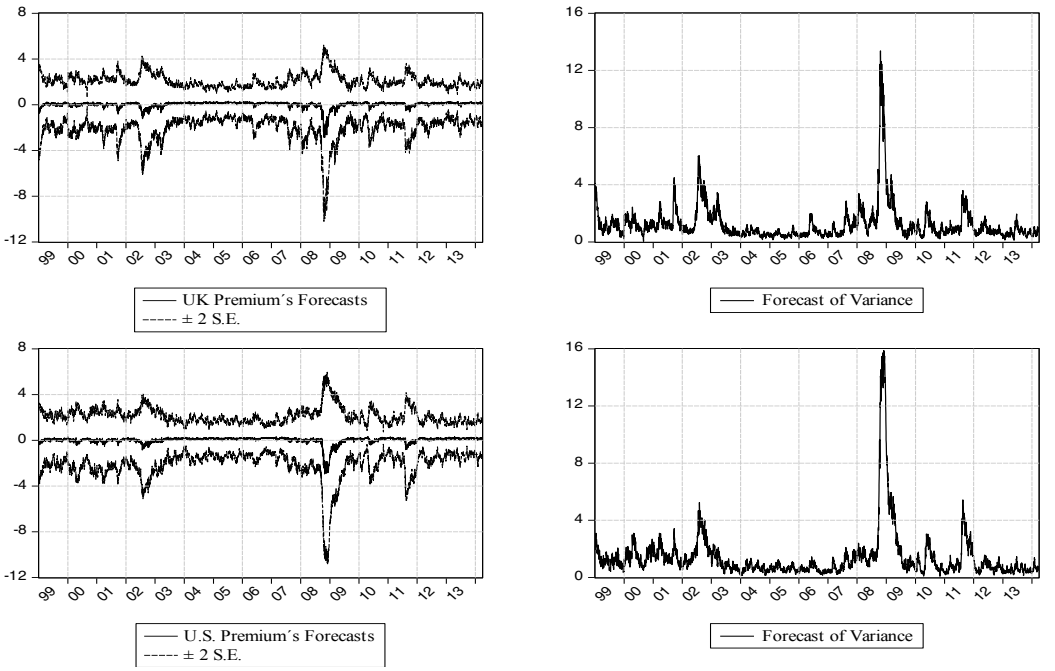
Appendix A.

A.1. GARCH-M models' forecasts and forecast of variance in graph



A.2. Correlation analysis between growth of equity premiums in the UK and U.S.

Covariance Analysis: Correlation matrix					*Autocorrelation*		
	UK	UK(-1)	US	US(-1)	lags	UK premium	US premium
UK	1.0000						
	-----				*1*	-0.4980	-0.0810
	-----				*2*	0.0150	-0.0380
					3	-0.0830	-0.0010
UK(-1)	-0.0421	1.0000			*4*	0.1200	-0.0110
	-2.6559	-----			*5*	-0.0610	-0.0370
	0.0079	-----			*6*	-0.0220	-0.0070
					7	0.0210	-0.0260
US	0.5177	-0.0376	1.0000		*8*	0.0340	0.0410
	38.1383	-2.3729	-----		*9*	-0.0180	-0.0280
	0.0000	0.0177	-----		*10*	-0.0140	0.0200
US(-1)	0.2734	0.5179	-0.0813	1.0000			
	17.9161	38.1584	-5.1440	-----			
	0.0000	0.0000	0.0000	-----			

Note: The first value means correlation, next t-Statistic, and the third probability value in correlation matrix. All autocorrelation values are statistically significant at 1% level.

A.3. Heteroskedasticity tests: ARCH within residuals of estimated GARCH-M models

OLS regression for the UK			
F-statistic	232.3965	Prob. F(1,3971)	0.0000
Obs*R-squared	219.6584	Prob. Chi-Square(1)	0.0000
OLS regression for U.S.			
F-statistic	124.4576	Prob. F(1,3971)	0.0000
Obs*R-squared	120.7362	Prob. Chi-Square(1)	0.0000

GARCH-M (1,2) for the UK with ARCH 1 Lag			
F-statistic	0.026970	Prob. F(1,3971)	0.8696
Obs*R-squared	0.026983	Prob. Chi-Square(1)	0.8695
GARCH-M (1,2) for the UK with ARCH 2 Lags			
F-statistic	1.578221	Prob. F(2,3969)	0.2065
Obs*R-squared	3.156319	Prob. Chi-Square(2)	0.2064

GARCH-M (1,2) for U.S. with ARCH 1 Lag			
F-statistic	0.109703	Prob. F(1,3971)	0.7405
Obs*R-squared	0.109755	Prob. Chi-Square(1)	0.7404
GARCH-M (1,2) for U.S. with ARCH 2 Lags			
F-statistic	1.102633	Prob. F(2,3969)	0.3321
Obs*R-squared	2.205707	Prob. Chi-Square(2)	0.3319